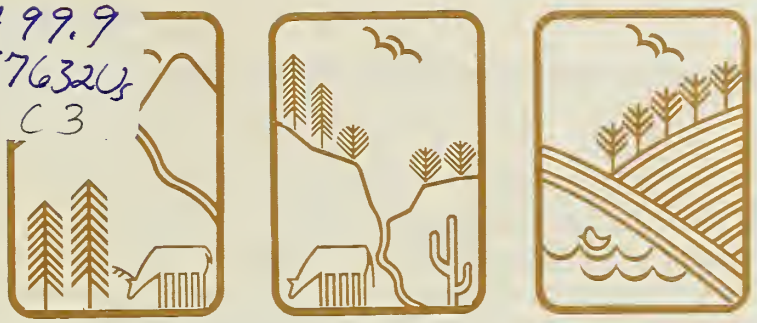

Research Note
RM-RN-530
December 1994

USDA Forest Service
Rocky Mountain Forest and Range Experiment Station

Natural Infection of New Hosts by Hemlock Dwarf Mistletoe

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New and additional host/parasite combinations for hemlock dwarf mistletoe based on natural infection are reported from Oregon, Washington, and Alaska. A summary of the host range of hemlock dwarf mistletoe based on natural infection and artificial inoculations is included.

Keywords: *Arceuthobium tsugense*, hemlock dwarf mistletoe, hosts

Introduction

Hemlock dwarf mistletoe (*Arceuthobium tsugense* (Rosendahl) G.N. Jones) parasitizes several commercially important conifers in the Pacific Northwest (Hawksworth and Wiens 1972, Smith 1969). This dwarf mistletoe is distributed from the central Sierra Nevada in California through Oregon, Washington, and British Columbia into southeast Alaska. Its known elevational range is from near sea level in British Columbia and Alaska to about 2,500 m in the central Sierra Nevada.

The present taxonomic treatment of this mistletoe consists of two subspecies (Hawksworth et al. 1992): subspecies *tsugense* - western hemlock dwarf mistletoe and subspecies *mertensianae* - mountain hemlock dwarf mistletoe. The mountain hemlock dwarf mistletoe primarily parasitizes mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.) but also commonly parasitizes Pacific silver fir (*Abies amabilis* (Dougl.) Forbes), noble fir (*Abies procera* Rehd.), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt. var. *lasiocarpa*) and whitebark pine (*Pinus albicaulis* Engelm.) (Hawksworth et al. 1992) (Table 1). Mountain hemlock dwarf mistletoe occasionally parasitizes western white pine (*Pinus monticola* Dougl.) (Hawksworth et al. 1992, Mathiasen and Hawksworth 1988) and is rarely found on Brewer's spruce (*Picea breweriana* S. Wats.) (Hawksworth 1987).

Western hemlock dwarf mistletoe (subsp. *tsugense*) consists of two morphologically indistinguishable host races: the western hemlock race and the shore pine race (Hawksworth et al. 1992).

The western hemlock race frequently infects western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) but also commonly parasitizes Pacific silver fir and noble fir when these hosts occur near infected western hemlock (Hawksworth et al. 1992) (Table 1). It has been found parasitizing grand fir (*Abies grandis*

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Table 1.—Summary of host susceptibility to mountain hemlock dwarf mistletoe and western hemlock dwarf mistletoe based on observations of natural infection.

Dwarf mistletoe	Host susceptibility class[1]			
	Principal	Secondary	Occasional	Rare
A. tsugense subsp. *mertensianae*	*Abies amabilis*	*Pinus albicaulis*	*Pinus monticola*	*Picea breweriana*
	Abies lasiocarpa var. *lasiocarpa*			*Pinus contorta* subsp. *latifolia*[2]
	Abies procera			*Tsuga heterophylla*[2]
	Tsuga mertensiana			
A. tsugense subsp. *tsugense* (western hemlock race)	*Abies amabilis*		*Abies grandis*[3]	*Larix occidentalis*
	Abies lasiocarpa var. *lasiocarpa*[4]		*Pinus contorta* subsp. *latifolia*[5]	*Picea engelmannii*[6]
	Abies procera			*Picea sitchensis*[7]
	Tsuga heterophylla			*Pinus monticola*
				Pseudotsuga menziesii
				Tsuga mertensiana
A. tsugense subsp. *tsugense* (shore pine race)	*Pinus contorta* subsp. *contorta*			*Pinus monticola*
				Tsauga heterophylla

[1]*Susceptibility classes are explained in text.*

[2]*Reported for the first time in this note based on natural infection.*

[3]*Classification of grand fir as an occasional host of western hemlock dwarf mistletoe (western hemlock race) is based on Hawksworth and Wiens (1972) (Table 5 and Appendix - Specimens Examined), but this classification needs further study.*

[4]*Reported as a principal host for the first time in this note.*

[5]*Previously reported host based on artificial inoculations by Smith (1965) and Smith and Wass (1979). Reported for the first time in this note based on natural infection.*

[6]*Classification of Engelmann spruce as a rare host of western hemlock dwarf mistletoe (western hemlock race) is based on Hawksworth and Wiens (1972) (Table 5 and Appendix - Specimens Examined) and on field observations near Trinity, WA, reported in this note.*

[7]*Reported from new locations in Alaska in this note.*

(Dougl.) Lindl.) (Hawksworth and Wiens 1972), but populations of this host/parasite combination need further study (Mathiasen, unpublished). This race is rare on mountain hemlock (Fiddick and van Sickle 1979, Hawksworth et al. 1992, Shaw 1982), western white pine (Gill 1935, Hawksworth et al. 1992), Sitka spruce (*Picea sitchensis* (Bong.) Carr.) (Hawksworth 1987, Laurent 1966, Molnar et al. 1968) and coastal Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*) (Hunt and Smith 1978). Hawksworth and Wiens (1972) reported Engelmann spruce (*Picea engelmannii* Parry) as a rare host for hemlock dwarf mistletoe, but in 1972 the two races of mistletoe had not been designated. Based on the listing of specimens they examined (Appendix - Specimens Examined), the western hemlock race is the taxon Hawksworth and Wiens reported on Engelmann spruce.

The shore pine race primarily parasitizes shore pine (*Pinus contorta* Dougl. ex Loud. subsp. *contorta*) (Hawksworth et al. 1992, Smith and Wass 1976, Wass 1976). It rarely occurs on western white pine (Hawksworth et al. 1992, Hunt and Smith 1978, Kuijt 1956) and western hemlock (Hawksworth et al. 1992, Smith and Wass 1979, Wass 1976) (Table 1).

Inoculation studies have demonstrated that several other trees are susceptible to hemlock dwarf mistletoe (western hemlock race). By artificially inoculating seedlings and trees in greenhouses, plantations, or in the field the following trees have been shown to be susceptible to western hemlock dwarf mistletoe: eastern hemlock (*Tsuga canadensis* (L.) Carr.) (Wier 1918), western hemlock from the interior of British Columbia (Smith 1965, Smith and Wass 1979), lodgepole pine (*Pinus contorta* Dougl. ex Loud. subsp. *latifolia* (Engelm. ex Wats.) Critchf.) (Smith 1965, 1974, Smith and Wass 1979), white spruce (*Picea glauca* (Moench) Voss) (Smith 1965, 1974), Norway spruce (*Picea abies* (L.) Karst.) (Smith 1965), western larch (*Larix occidentalis* Nutt.) (Smith 1970, 1974), ponderosa pine (*Pinus ponderosa* Laws.) (Smith 1974, Smith and Craig 1968), Monterey pine (*Pinus radiata* D. Don) (Smith 1974, Smith and Craig 1968), Scots pine (*Pinus sylvestris* L.) (Smith 1974, Smith and Craig 1968) and interior Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *glauca* (Beissn.) Franco) (Smith 1974, Smith and Wass 1972). Smith (1974) successfully infected western white pine and grand fir with the shore pine race of western hemlock dwarf mistletoe, but not with the western hemlock race. In addition, Smith (1974) was unable to artificially infect Sitka spruce even though the western hemlock race does rarely infect this host in nature (Hawksworth 1987, Laurent 1966, Molnar et al. 1968). Artificial inoculations using seeds of mountain hemlock dwarf mistletoe (subsp. *mertensianae*) have not been attempted.

This note reports new hosts for hemlock dwarf mistletoe based on field observations made in Oregon and Washington in 1993. Some of these host/parasite combinations have been previously reported, based on artificial inoculations as mentioned above, but this is the first report of these host/parasite combinations occurring naturally. Additional occurrences of hemlock dwarf mistletoe on rare hosts from new locations in Oregon, Washington, and Alaska are reported also. Table 1 summarizes the host susceptibility for the western hemlock and mountain hemlock dwarf mistletoes based on observations of natural infection. Specimens representing the different host/parasite combinations are deposited at the USDA Forest Service Forest Pathology Herbarium (FPF) at Fort Collins, CO. Identification of the hemlock dwarf mistletoe populations described below was based on shoot morphology (primarily shoot size and color), host infection and elevation (Hawksworth and Wiens 1972, Hawksworth et al. 1992).

Western Hemlock Dwarf Mistletoe

Western hemlock dwarf mistletoe (western hemlock race) was found parasitizing lodgepole pine (*Pinus contorta* subsp. *latifolia*) near Trinity, Chelan County, WA (near the confluence of Phelps Creek and the Chiwawa River approximately 26 km north of Lake Wenatchee, 48°, 04′ N., 120°, 51′ W.). Several infected lodgepole pine were growing near heavily infected Pacific silver fir. Shoot production was common and prolific on all infected lodgepole pine. No infected lodgepole pine were observed near infected western hemlock.

To estimate natural susceptibility of lodgepole pine to western hemlock dwarf mistletoe (Hawksworth and Wiens 1972), temporary circular plots (radius 6 m) were established around 10 heavily infected Pacific silver fir growing near infected lodgepole pine. Each tree greater than 10 cm in diameter at breast height (1.4 m above the ground) in each plot was examined for dwarf mistletoe infections and the following data recorded: species, diameter (nearest 2.5 cm), and dwarf mistletoe rating (Hawksworth 1977). Almost 10% of the lodgepole pine growing near infected Pacific silver fir were infected (Table 2). This level indicates that lodgepole pine should be classified as an occasional host of western hemlock dwarf mistletoe based on the host susceptibility classification system used by Hawksworth and Wiens (1972). Their system ranks susceptibility according to the percentage of infected trees within 6 m of heavily infected principal hosts. Susceptibility classes are as follows: principal host - 91-100% infection; secondary - 51-90% infection; occasional - 5-50% infection; rare - 1-4% infection; immune - no infection.

Heavy infection of subalpine fir and Pacific silver fir by western hemlock dwarf mistletoe was observed at the Trinity location. Ten temporary circular plots (radius 6 m) were placed around infected western hemlock to estimate natural susceptibility of subalpine fir and Pacific silver fir to western hemlock dwarf mistletoe in this area. Data were collected as described above. Infection was greater than 90% for both subalpine fir and Pacific silver fir, indicating

Table 2.—Percentage of trees greater than 10 cm in diameter infected by the western hemlock dwarf mistletoe that were growing within 6 m of severely infected western hemlock or Pacific silver fir near Trinity, WA (20 plots).

Tree species	Number sampled	Mean diameter (cm)	Percent infected	Mean dwarf mistletoe rating
Pacific silver fir	196	26	96	3.9
Subalpine fir	118	24	91	3.1
Western hemlock	21	14	57[1]	1.3
Lodgepole pine	64	17	9	0.3
Engelmann spruce	36	22	3	1.0
Douglas-fir	16	38	0	0
Western white pine	12	20	0[2]	0
Grand fir	9	14	0	0
Mountain hemlock	7	18	0[2]	0

[1]*Western hemlock was not well represented in the understory and trees were small and lightly infected.*

[2]*Infected trees of this species were observed elsewhere in the area.*

that both species are principal hosts (Table 2). In addition, mean dwarf mistletoe ratings for these species (greater than 3.0) indicates that they are highly susceptible to western hemlock dwarf mistletoe (Table 2). This is the first report of infection of subalpine fir by western hemlock dwarf mistletoe. Other reports of hemlock dwarf mistletoe on subalpine fir are based on parasitism by mountain hemlock dwarf mistletoe (Hawksworth et al. 1992). Why infection of western hemlock in these stands was less than that on Pacific silver fir or on subalpine fir is not clear (Table 2), but may relate to the lower density and small size of western hemlock in sampled stands.

Other trees were observed to be infrequently infected by western hemlock dwarf mistletoe in the Trinity area as follows (Table 2): Engelmann spruce - six trees; western white pine - two trees; mountain hemlock - two trees. Considerable shoot production was observed on all infected trees. This is the first report of western hemlock dwarf mistletoe on these hosts in Washington (Hawksworth et al. 1992).

Another population of western hemlock dwarf mistletoe parasitizing mountain hemlock was found at Wapinita Pass, Clackamas County, OR, approximately 17 km south of Mount Hood (45°, 14′ N., 121°, 42′ W.). Infection of western hemlock and Pacific silver fir was common in this area but rare on mountain hemlock (only two infected trees observed), although many mountain hemlock were in the stand. Few shoots were found on mountain hemlock, but they were well developed and allowed for identification of western hemlock dwarf mistletoe. This is the first report of western hemlock dwarf mistletoe on mountain hemlock in Oregon. All other reports of parasitism by hemlock dwarf mistletoe on mountain hemlock from Oregon are based on infection by mountain hemlock dwarf mistletoe (Hawksworth et al. 1992).

Another collection of western hemlock dwarf mistletoe parasitizing Sitka spruce was located near Halleck Harbor in Saginaw Bay, Kuiu Island, AK (56°, 28′ N., 134°, 13′ W.). One infected tree was growing among several heavily infected western hemlock. Several branches on the spruce had large swellings, but no shoots. Dr. Frank Hawksworth, Rocky Mountain Forest and Range Experiment Station, examined these specimens and confirmed that they contained dwarf mistletoe tissues (cortical strands and sinkers).

Few specimens of western hemlock dwarf mistletoe have been collected from Sitka spruce (Hawksworth and Wiens 1972, Laurent 1966, Molnar et al. 1968). Specimens of this host/parasite combination at FPF indicate that infections infrequently produce shoots (personal communication with C.G. Shaw III, 1994). Only two of five specimens of hemlock dwarf mistletoe on Sitka spruce at FPF have shoots. Only one of these, a collection made by M. McWilliams and R. Nathenson near Edna Bay, Kosciusko Island, AK (55°, 57′ N., 133°, 29′ W.), has nearly mature fruits. This demonstrates that hemlock dwarf mistletoe can reproduce on Sitka spruce.

Mountain Hemlock Dwarf Mistletoe

Mountain hemlock dwarf mistletoe (subsp. *mertensianae*) was rarely found parasitizing lodgepole pine (*Pinus contorta* subsp. *latifolia*) near McKenzie Pass, Lane County, OR (44°, 15′ N., 121°, 48′ W.). Hemlock dwarf mistletoe (undoubtedly the mountain hemlock subspecies) has long been known to severely parasitize mountain hemlock, subalpine fir, and whitebark pine at this locality (Gill 1935, Hawksworth and Wiens 1972); however, this is the first report of mountain hemlock dwarf mistletoe on lodgepole pine. Only one small infected lodgepole pine growing near a heavily infected whitebark pine was observed. However, the lodgepole pine had several infections and each infection had produced several mistletoe shoots that could be identified as mountain hemlock dwarf mistletoe. Although the principal dwarf mistletoe of lodgepole pine, *Arceuthobium americanum* Nutt. ex Engelm., does occur approximately 6 km west of McKenzie Pass (Hawksworth and Wiens 1972), it has not been observed in the immediate vicinity of McKenzie Pass and is morphologically quite distinct from mountain hemlock dwarf mistletoe (Hawksworth et al. 1992, Hawksworth and Wiens 1972).

Hawksworth et al. (1992) reported that mountain hemlock dwarf mistletoe (subsp. *mertensianae*) had not been found parasitizing western hemlock, even where this tree is closely associated with infected mountain hemlock. A western hemlock infected by mountain hemlock dwarf mistletoe has now been located approximately 4 km southeast of Shuksan, Whatcom County, WA near the Mount Baker Highway at Bagley Creek (48°, 52′ N., 121°, 38′ W.). Infection of mountain hemlock and Pacific silver fir was common in this area. Although there were several western hemlock growing near severely infected mountain hemlock and Pacific silver fir throughout the area, only one infected western hemlock was observed. Therefore, western hemlock should be classified as a rare host of mountain hemlock dwarf mistletoe. Several infections were on the western hemlock, but only a few had produced shoots and none of these had mature fruits.

Acknowledgments

The assistance of Dr. Paul Hennon, USDA Forest Service, Juneau, AK with the collection of specimens of hemlock dwarf mistletoe on Sitka spruce on Kuiu Island, AK, is greatly appreciated. Dr. Charles G. Shaw III, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO, provided information on hemlock dwarf mistletoe/Sitka spruce specimens at FPF and provided many useful suggestions for improving the manuscript.

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